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GRAPHICAL DISPLAYS OF SYNCHRONIZATION OF TACTICAL UNITS

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Synchronization is a major tenet of US Army Doctrine. This report presents computer graphic displays of the synchronization of tactical size units. These displays should prove useful in critiquing the performance of units during force on force training, and in highlighting possible areas for improvement in use of basic tactics.

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GRAPHICAL DISPLAYS OF SYNCHRONIZATION OF TACTICAL UNITS

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Background

Current U. S. Army doctrine is responding to the realities of shrinking resource availabilities and rapid evolution of political and social structures in many parts of the world. The AirLand Operations doctrine envisions a nonlinear battlefield encompassing large areas, with widely dispersed fighting units. This type of conflict places great demands on many of the classically recognized attributes of fighting forces, including Command and Control, Communications, Intelligence gathering, Mobility, Synchronization, Agility of forces, Initiative and Depth.

The Army has for many years employed Combat Training Centers to provide tactical forces with realistic exercises, enhancing their abilities for engagement in real combat. Such exercises typically result in subjective After Action Reports (AARs) which can be used to critique unit performance and suggest additional training guidelines. The National Training Center (NTC) at Fort Irwin, California, is highly instrumented to gather many types of data for simulated combat, including time-position data from many different units during an exercise, as well as weapon firings and target kills for both forces. A General Accounting Office report [1] has mentioned that the National Training Center achieves the objective of providing training under realistic conditions. This report also mentions that the Army has not realized the full potential it had envisioned for the National Training Center, falling short of the goal of *objectively* assessing the effectiveness and efficiency of its organizations and weapon systems. Two major causes are cited for this perceived shortfall:

- The Army has not identified the types of data needed to assess unit performance over the long term.

- Objective data collected through the Center's instrumentation system is too unreliable and incomplete for overall analysis.

Army doctrine stresses four basic battlefield tenets: Initiative, Agility, Depth and Synchronization, all of which contribute heavily to success on the modern battlefield. Objective indications of how well a particular brigade/ battalion force performed according to these tenets, for a given battle, would form a useful training tool. Such indications would also help answer the shortfalls addressed by the General Accounting Office report.

TRAC Monterey has contracted with the Naval Postgraduate School to investigate useful, graphic presentations of the synchronization and agility of battalion/brigade size forces at the National Training Center. This report discusses the current state of this research and illustrates a number of graphic presentations of synchronization which should prove useful in After Action Reviews of performance at the National Training Center. These displays may also prove appropriate for the unit take-home packages for review, as well as reference for future training.

Project description

A major goal of the Battle Enhanced Analysis Methodology (BEAM) project is the development of computer displays which meaningfully picture synchronization and agility in a tactical level battle. This in turn requires the identification of measurable quantities which portray these two attributes. Both of these terms are rather broad and general, subject to a number of interpretations, possibly dependent on the context in which they are used. To gain insight into the way in which the Army employs these words in the defining tenets, many field manuals and other documents have been reviewed; several of these are discussed briefly below and are listed in the references. This review of written material has been supplemented with expert Army (and other service) opinion, also discussed in the following section.

As a result of the documentation review and assessment of expert opinion, it was decided to concentrate initial efforts on picturing aspects of synchronization. This remains a broad term which can be applied in several ways, one of the most basic of which is the synchronization of weapon firing. Displays of direct fire synchronization have been developed and are illustrated. These displays may also prove easily adaptable to displays of indirect fire, which will be addressed in the latter part of this project.

Another aspect of synchronization refers to movement of forces; displays for this type of synchronization have also been developed and will be discussed. These displays of synchronization (of both direct fire and movement) can be animated over time, during the course of the battle. Such animation is expected to prove useful as measures or indicators of agility, another one of the battle tenets.

Doctrine review, expert opinions

A survey of current U. S. Army doctrine was undertaken, to find the latest interpretations of the four battlefield tenets: Initiative, Agility, Depth and Synchronization. The main focus of the initial effort is synchronization, which has many facets, some of which are more easily quantified and portrayed than others. Field Manual 100-5 (FM 100-5 [2]) defines synchronization as follows:

> Synchronization is the arrangement of battlefield activities in time, space, and purpose to produce maximum relative combat

> power at the decisive point. Synchronization is both a process and a result. (May 5, 1986, page 17)

This manual stresses the importance of synchronization in both offensive and defensive operations. Indeed, it points out that a good defensive procedure is to interrupt the synchronization of the attacker.

Field Manual 71-3 ([3]) refers to synchronization fairly extensively; it states that synchronization of operations is required to obtain maximum combat power from the combined arms team, but does not give a definition of the word, per se. Brigades synchronize their operations (page 1-3) by

- Completing an extensive Intelligence Preparation of the Battlefield (IPB) to include the Decision Support Template (DST).
- Designating and resourcing the brigade main effort.
- Coordinating and integrating Combat Service (CS) and Combat Service Support (CSS) efforts.
- Using the logistics estimate to ensure adequate resources are available and allocated.
- Rapidly massing combat power to achieve local surprise and shock effect without lengthy explanations or orders.
- Planning in advance to exploit the opportunities created by tactical success.
- Allowing decentralized operations.
- Using smoke to conceal maneuver and allow massing of combat power.

This manual includes two 4-page foldouts, one for offense and one for defense, to portray "what synchronization looks like" (pages 3-8,9 and pages 4-15,16). These figures give a generalized battlefield template, and a discussion of a number of operations at various depths of the battlefield. No indication of a time parameter is employed in either of these figures.

In Field Manual 71-2 (FM 71-2 [4]), synchronization is called one of the four characteristics of successful operations (the other three are the remaining tenets listed in FM 100-5). On page 1-6 it is stated that "Synchronization is the process of integrating the activities on the battlefield to produce the desired result. Synchronization of operations is required in order to maximize the combat power of the combined arms team. It requires a command, control, and communications system that can mass and focus the combat power of the task force at the decisive time and place." In discussing synchronization of offensive operations (page 3-28), it is stated that the commander and his staff synchronize and integrate all combat, combat support and combat service support assets organic and available to the battalion task force. No indication is given of how this is to be achieved. In discussing synchronization of defensive operations, (page 4-24) it states that "The success of the defense is determined by how effectively all supporting organizations are integrated into the maneuver plan." A discussion of the sequence of the defense is given, but no reference is made to synchronization. Synchronization of attack helicopters (page 6-22) refers to coordination of activities of ground and aviation commanders.

Mission Training Plan 71-2-MTP [5] describes training plans for a battalion, at several different levels, the highest of which is the Field Training Exercise (FTX); it includes suggested ways of carrying out such training and gives examples of After Action Reviews for evaluation of the training. The battalion tasks are supported by tables which list varying numbers of subtasks, with GO – NO/GO options to be checked. A few of these subtasks refer to synchronization, but no guidance is given about standards the reviewer should employ in choosing the GO versus NO/GO choice.

On page 1-2, Field Manual 71-1 (FM 71-1 [6]) gives essentially the same definition of synchronization as [2]. It points out that this requires careful timing and teamwork, especially at the company level. This document appears to use co-ordination as a synonym for synchronization, although that is not explicitly stated. The thesis by C. L. Long ([7]) provides a review of many Army manuals and points out the lack of consistency in definition of synchronization (and the frequent lack of any definition at all). He suggests and illustrates the use of a synchronization matrix and gives a detailed discussion of such a construct for a battle defending southern California from a Soviet-style Arizona attack. His discussion and synchronization matrix explicitly recognize and employ a time parameter. Student text 100-9 ([8]) stresses synchronization, and includes discussion of (essentially) Long's synchronization matrix as a useful tool. It points out the fact that time is a critical aspect of synchronization and states that synchronization is essential to retain the initiative in a battle. It discusses the importance of synchronization of combat power and recognizes the fact that Intelligence Preparation of the Battlefield (IPB) is a continuous process. This text states that war gaming is a key step in the synchronization of the efforts of the G2 and G3 functions and that synchronization is maintained as the battle progresses by continuing intelligence updates of the IPB.

In addition to a review of the above documents (and several others), a group discussion was held with Naval Postgraduate School Army and Marine Corps officer students. This centered on the various aspects of synchronization and meaningful ways of objectively assessing synchronization, especially in a defensive posture. Ideas were generated on observable variables which capture at least parts of synchronization and possible further sources to explore objective assessment of synchronization.

To observe the current instruction given at the tactical level, and to gather opinions of the instructors there for measuring synchronization, one week was spent at the Tactical Commanders Development Course (TCDC) at Fort Leavenworth, Kansas. This involved attending the class being held at the time and discussing possible computer displays of synchronization with the course instructors and TITAN contractor personnel. One possibility considered for an objective measure of synchronization was the development of a scoring system of the synchronization of the Battlefield Operating Systems (BOSs) individually and in pairs; the seven BOSs considered were Command & Control, Maneuver, Fire Support, Intelligence, Air Defense, Mobility, Countermobility & Survivability, and Combat Service Support. This approach was discussed with several TCDC instructors and TITAN contractor personnel; cards for suggested input had been previously prepared, to be returned for possible inclusion in development of displays. This effort did not prove successful in generating suggestions. The TCDC course quite explicitly addresses synchronization, and refers to it as both a process and a result, in accord with FM 100-5 [2]. The course stresses that effective synchronization requires many things, including

- Anticipation of enemy actions
- Mastery of time-space relationships on the battlefield.
- Unity of purpose
- Understanding of weapons capabilities
- Knowledge of battlefield decision points.

This exposure proved very useful in illustrating the complexities involved in tactical level planning and execution, and in highlighting the many facets of synchronization.

Three days were spent at the National Training Center , Fort Irwin, California, which allowed observation of a battle in progress, and several After Action Reviews, to see how synchronization issues are currently portrayed. Discussions of synchronization were held with members of the operations group; examples of current JANUS displays for AARs were available for viewing. A version of the currently developed Line of Sight (LOS) display was installed on a MacIntosh, to gather comments from operations group personnel, and for possible future use in AARs. A tour of several areas of Fort Irwin was useful in observing the actual terrain over which many of the battles at NTC are run.

Implications of review and opinions

Computer displays which meaningfully picture synchronization to combat personnel should be easy to understand and be obviously linked to one or more of the common ways in which the term is used. Synchronization is a broad term; it clearly encompasses coordination and integration of separate parts, both before and during the battle. Indeed it is also meant to be a result, as stated in FM 100-5, with the goal of maximizing relative combat power at the decisive point. In FM 100-5, "combat power" is defined to have four components: Maneuver, Firepower, Protection and Leadership. Of these, FM 100-5 identifies Leadership as being the most essential. Unfortunately, as also pointed out in this manual, there are no ready formulas for measuring this essential element, so it has not been considered as a possible candidate for displays. The two components of Protection (making soldiers, systems, units difficult to locate and destroy, in addition to health and morale issues) are also not easy to quantify for display and have not been actively considered for visual portrayal.

The remaining two components of combat power, Maneuver and Firepower, can be quantified in a number of ways and have been studied as candidates for useful computer displays of synchronization of a tactical force. The following sections provide discussions of possible ways to display these two components of combat power.

Displays of Synchronization

As indicated in the above discussion, synchronization of battle forces is evidenced in many ways; the most obvious candidates for display are firepower and maneuver. Firepower may be provided in two essentially different manners: from direct fire weapons or from indirect fire weapons (including both artillery and air support). The initial effort of this study has concentrated on displaying the firepower of direct fire weapons. Displays of firepower for indirect fire weapons will be addressed in a subsequent report.

Our initial displays of direct fire weapon firepower were developed by Major D. A. Dryer, giving a visual indication of the lines of sight afforded weapons placed in selected defensive positions. These are discussed further below. The existence of line of sight is necessary for the employment of a direct fire weapon, but does not give any indication of the actual destructive power of these defensive weapons. Thus a further type of display (Destructive Potential) has been developed by Major R. M. Lamont ([10]); this display is also discussed below. Captain M. S. Nelson ([11]) has studied displays of maneuver, which are also discussed.

Line of Sight (LOS) display.

As discussed previously, a result of synchronization is the production of maximum relative combat power at the decisive point; one component of combat power is Firepower, the provision of destructive force essential to defeating the enemy's ability and will to fight. Direct fire weapons are a major component of this destructive force; the effectiveness of these weapons, in turn, depends on their lines of sight, the (possible) target areas they are able to see. If a force has placed its direct fire weapons in locations where they cannot see the main battle area, they will not be effective in contributing to the combat power in that area. Thus, the lines of sight for any particular placement of direct fire weapons control their effectiveness in any battle. If the lines of sight are massed at the decisive area of the battle (at the correct point in time) these weapons will be able to contribute to the combat power of the force; if lines of sight do not exist (at this time) they do not contribute to the combat power.

This line of reasoning leads to consideration of a graphical display of the lines of sight available to direct fire weapons, given their deployment positions (and their orientation at these positions). Digital terrain representations, as used in the JANUS combat model (and others), allow the determination of lines of sight between points within the area being depicted. If one has placed individual direct fire weapons at given locations, it is straightforward to determine the points on the battlefield which can be seen by each of them. Indeed, one can go further and build an LOS surface whose height at any point on the ground is given by the number of direct fire weapons which are able to see that point; the higher the surface at a given point, the greater is the massing of lines of sight at that point. This surface can then be colored according to its height and displayed in two dimensions over the contour map of the area. The changes in color over a given region reflect the changes in the massing of the lines of sight, for the given locations of the weapons used.

This type of display (in grey scale) is given in Figure 1; having actual colors for differentiation, as is easily done with modern computer displays, gives more information than just the grey scale shading of this figure. This figure portrays a portion of the NTC with 10 friendly tanks located in the top center of the screen, in an area bounded by y-coordinates 105 and 107 and x-coordinates 51 and 53. The number of tanks that can see any given point, and which are within effective firing range, then varies from 0 to 10. These numbers in turn were color coded with dark blue representing 1 tank having LOS; the colors used ranged through lighter blue to green to yellow to red to signify 10 tanks with lines of sight to the given point. Absence of a color overlay means no tanks have LOS to that point. In the grey-scale image dark blue (one tank) and red (10 tanks) are both quite black and not distinguishable. The dark area in the center of the lines of sight is red, while the border dark area is in fact blue. The massing of the lines of sight (red), for the chosen defensive positions, lies between engagement areas Shark and Cuda, which were named in the commander's IPB. With this choice of defensive positions for the tanks, the lines of sight are not perfectly massed in either engagement area.

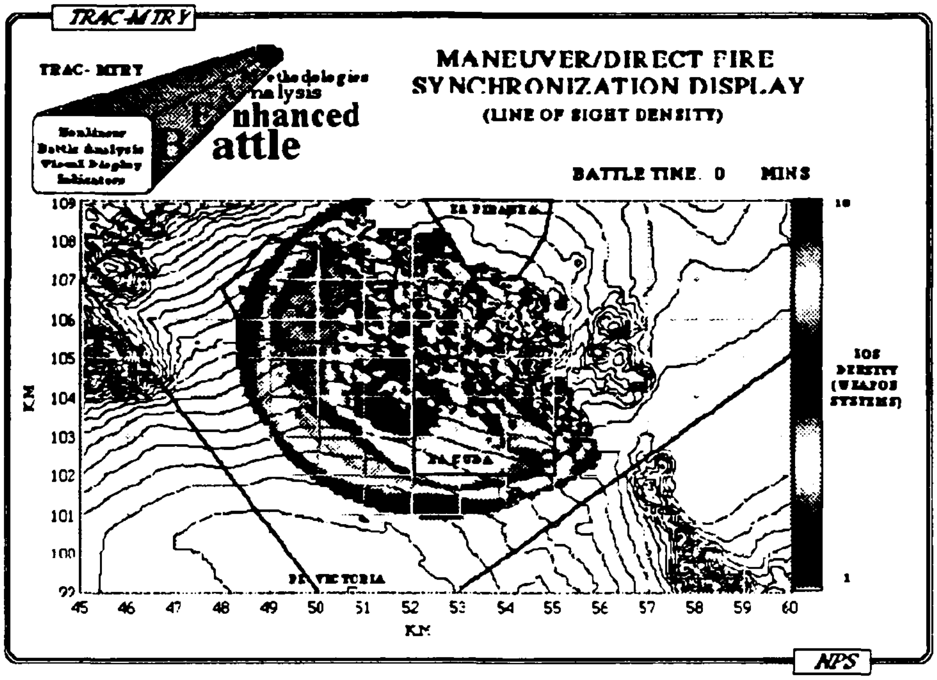

Figure 1. Line of sight display

Displays like Figure 1 give snapshot pictures which are useful in portraying the massing (or lack of massing) of one aspect of the combat power of the force at a given point in time. Constructing such snapshots at various points in time, and running them sequentially, can give a valuable indication of how the massing of the lines of sight changed during the battle, due to either movement or attrition of the weapons portrayed. The opposing force locations can also be overlaid on the same picture, giving a more complete description of the dynamics of the battle. Indeed, animation of LOS displays over time can be the basis of a measure of agility, showing how well the massing of lines of sight tracked a moving enemy force.

Destruction Potential (DP) displays

The LOS display simply describes the absence or presence of line of sight between points, giving no indication of how much damage a weapon, or the full force, might inflict on the corresponding point. There are a number of ways that a display can indicate the amount of destruction which could be inflicted at each point in a given area; this type of display will be called a Destruction Potential display.

One procedure which could be used to quantify destruction potential is similar in spirit to that used by T. N. Dupuy ([9]) in his Quantified Judgment Model (QJM) of the theory of combat. The procedure to be described was suggested and investigated by Major R. W. Lamont ([10]). Suppose a weapon (for example a tank) is located at point x; the LOS display just discussed then can determine those points a in any given area A for which line of sight exists between x and a. These points a. within the range of the weapon then would be potential targets for the weapon located at x. Suppose the weapon (at x) has probability $p_{r,w,t}$ of hitting and killing a target of type t located at point a., and that the weapon is capable of firing R_w rounds per minute; the subscript r is meant to indicate the range between x and a., recognizing the dependence of the probability on this factor, while w is used to indicate the type of weapon at point x and t indicates the type of target at point a.. Clearly, if a target were positioned at point a., the weapon either would or would not kill this target. To develop a *comparative* measure it is useful to pretend that an endless series of targets is available at point a.; when (and if) a given target is destroyed at this point it is instantly replaced by another. If there were such an endless series of targets of the given type located at a, and the weapon were to commence firing at its maximum rate, the *expected* number of kills this weapon would make at this point, in a one minute period, is the product $R_w p_{r,w,t}$.

Now suppose the Blue force has some number n of direct fire weapons, each of which has line of sight to the same point a. The accumulated expected number of kills that Blue could make in a one minute period against targets of type t, at this point, then is the sum $D_{1,t} = \Sigma_w R_w p_{r,w,t}$; this is essentially the kernel of Dupuy's QJM measure of combat power. This sum can be evaluated for each point a in an area A (for given firing weapon types w and targets t), defining a surface over area A, which could be plotted in place of the LOS. It gives a measure of the destructive potential of the Blue force, for this type of weapon versus this type of target, over area A. This procedure then gives a surface for all points a in a given area A, describing the destructive potential of a given type of weapon w versus a given type of target t. Such a surface could be plotted individually for each combination of target type and weapon used, or these could be combined in various ways.

For example, if a company of Bradley fighting vehicles were in given defensive positions, defending an area of interest, a surface for each of their two weapons could be constructed, against any given type target t. These two surfaces then could be combined (say a weighted average, as suggested in [10]) to give a single surface representing the Bradley's total expected kills of targets of the given type in the given area. In similar manner the expected numbers of kills could be aggregated over several different possible target types in area A. See [10] for more discussion of this type of combination of firepower over weapon types, and to see examples of resulting color-coded two-dimensional displays of this type of DP. Figure 2 presents a grey-scale picture of the DP surface for two defending tank companies, in the same area of the NTC that

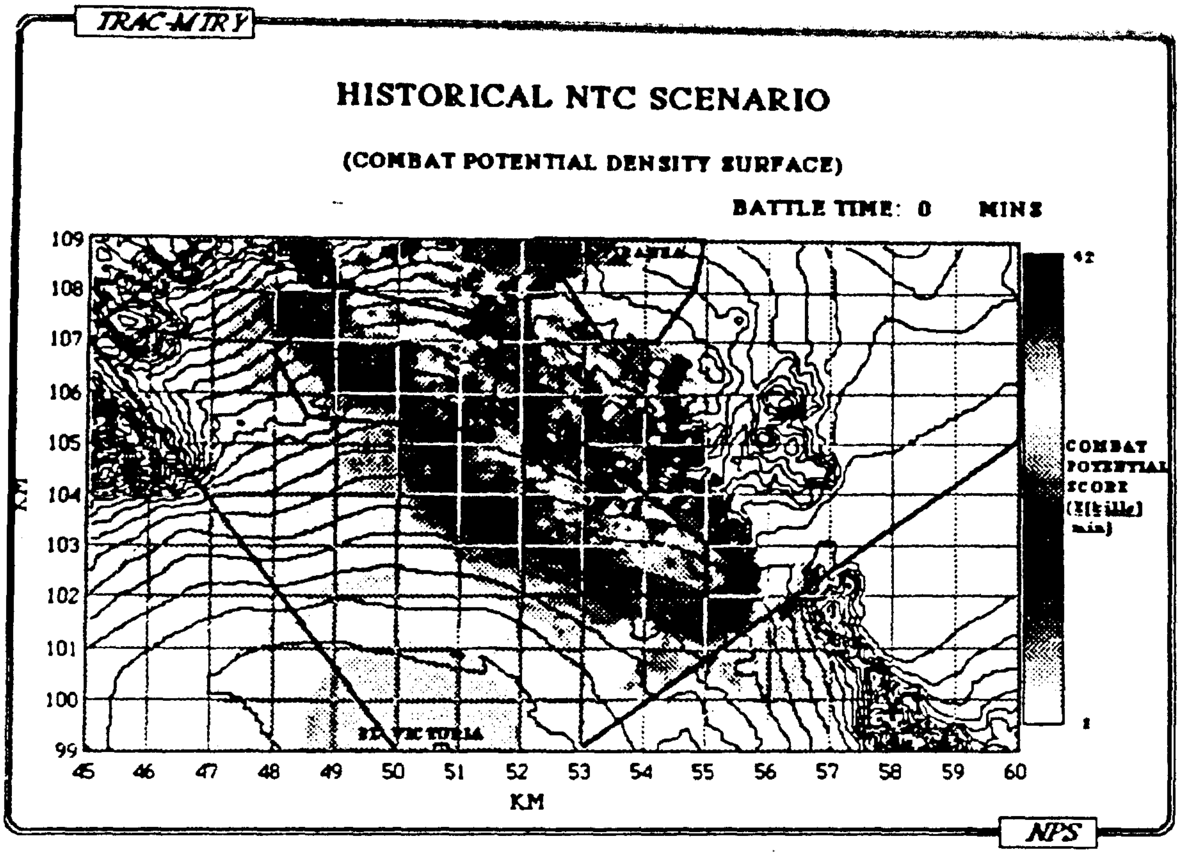

Figure 2. Destruction potential display, beginning of battle.

was pictured in Figure 1, using the defending positions chosen by a group undergoing training. The colors used in this display are different, with those showing up darker uniquely indicating higher DP values; lighter shading indicates lower DP scores. Figure 3 shows the ultimate result of the DP surface for the historical battle (the defense did not succeed).

Lamont replayed this battle in Janus(A), using initial defensive positions which followed published doctrine more closely than did those used by the unit undergoing training. His initial DP surface (at the start of the battle) is visually indistinguishable from Figure 2, the historical placement. The resulting DP surface 120 minutes into the battle is given in Figure 4; note that it contains considerably darker areas, indicating higher resulting DP scores for

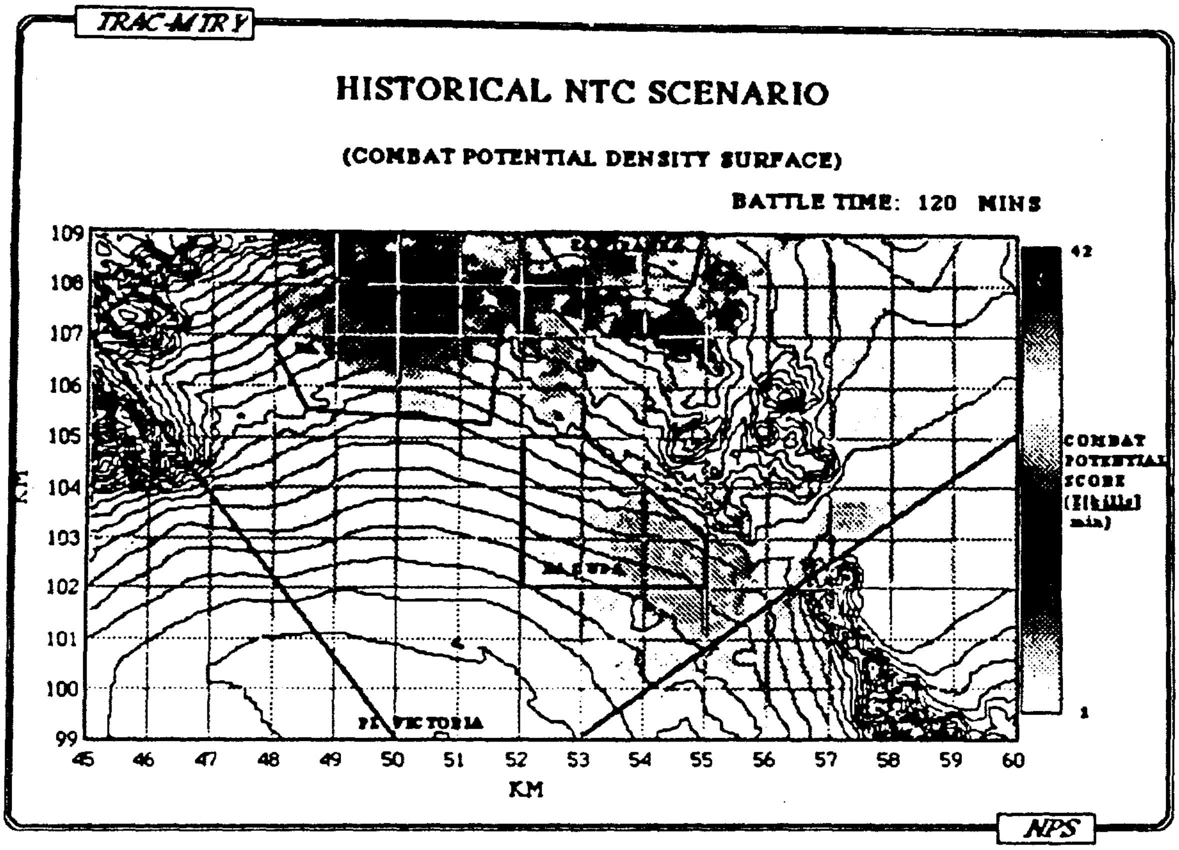

Figure 3. Destruction potential display, 120 minutes into historical battle.

his placement at the conclusion of the battle, which agreed well with other attrition based measures of the battle outcomes. See [10] for more details.

This expected value measure of destructive potential takes into account line of sight, firing weapon type and rate of fire, and the type of target. Other definitions of destructive potential could be used, two of which will now be described; these alternatives have not currently been implemented for comparison with $D_{1,t}$.

At any point in time there could be at most one target of a given type at a given point. A different measure of DP is given by simply evaluating the probability that a single target at the given point would be killed by the

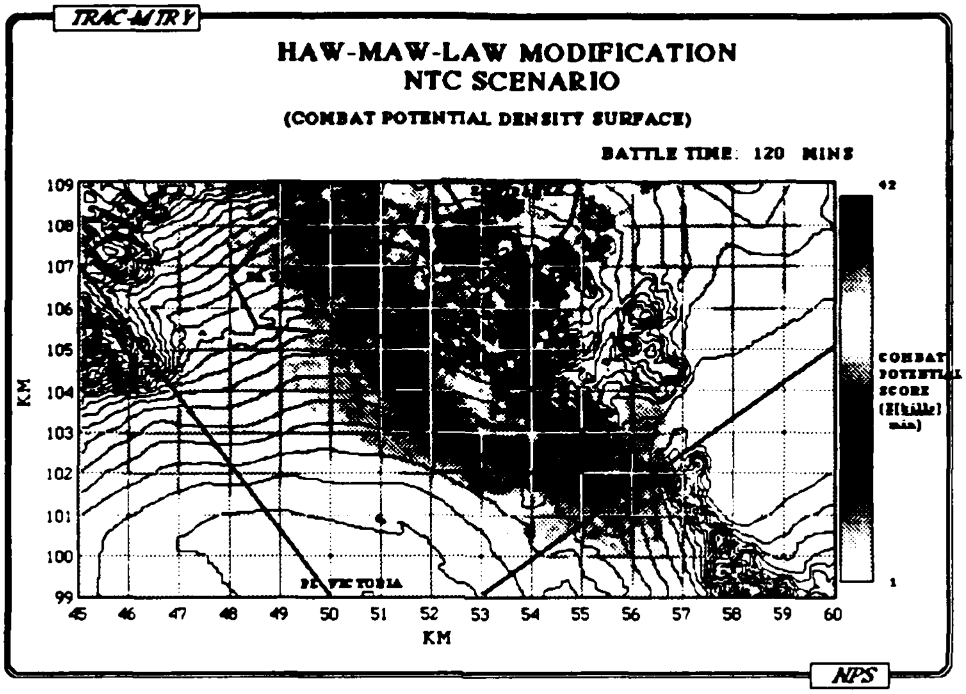

Figure 4. Destruction potential display, 120 minutes into battle, revised locations.

defending force, rather than evaluating the expected number of kills. Again, letting $p_{r,w,t}$ represent the probability of hitting and killing a target of the given type, at range r from weapon w, if all defending weapons were to independently fire one round at the (same) target at point a, the probability the target survives (is not killed) then is $\Pi_w(1-p_{r,w,t})$, the product of the probabilities of each weapon not killing the target. The probability the target *is* killed then is 1 minus this quantity $D_{2,t} = 1- \Pi_w(1-p_{r,w,t})$, which is an alternative measure of the destructive potential of an array of Blue forces against this type of target at this point. This function $D_{2,t}$ could also be used to define a surface over all the points a in a region A. While the expected value

DP surface suggested by Lamont is linear in the $p_{r,w,t}$ values, this second suggested surface is multiplicative in these values.

This second measure of destructive potential $(D_{2,t})$ combines the kill probabilities of the various Blue forces in a different way than $D_{1,t}$. It does not account for the rates of fire of the weapons, although it is easily modified to accomplish this, if desired. Suppose, as above, that weapon w has rate of fire R_w (again in rounds per minute). Then the probability that this weapon will miss the target at a with R_w independently aimed rounds is $(1-p_{r,w,t})^{R_w}$; if each of the weapons with line of sight to point a were to fire at maximum rate at a target at this point, the probability the target survives is then $D_{3,t}=1-\Pi_w(1-p_{r,w,t})^{R_w}$, which gives a third candidate measure of destructive potential. Which of these destructive potential displays might be most meaningful in any given case is a matter of military judgment. Any of them, animated through time, provides a useful indication of the combat power of the defending force through the course of the battle.

Any of these three suggested measures of DP could be used to display part of the objectively observable component of the Blue force's combat power over the region A. The same indicator of Red's combat power over the same region A, at the same time, could also be evaluated; then the ratio of these two surfaces provides a measure of the relative combat power of the two forces over area A. Granted the ratio is determined by Blue value divided by Red value, then Blue force's combat power exceeds that of the Red force for all points a where this ratio exceeds 1. This ratio could then also be plotted and color coded to indicate relative combat power of the two forces. One could use blue for those points a at which this ratio exceeds 1 and red for those points where it is less than 1 to simply indicate this relative combat power.

Rather than contrasting the combat powers of the two forces over the same region A, it may be more meaningful to examine Blue's combat power surface over the area A_R occupied by Red's combat systems, and to examine Red's combat power surface over the area A_B occupied by Blue's combat systems. This enables evaluation of the threat posed by each side against its opposition.

Maneuver displays

Both the LOS and DP displays discussed above and currently available computer generated tactical displays can be enhanced by the optional superposition of one or more displays illustrating maneuver of the friendly or enemy forces. Several maneuver displays are currently under development. Key features of the forces that should be shown include the type and size of the unit, the centroid, the spatial arrangement, and the rate and direction of movement (the track). Warfighters currently use standard military unit symbols and hand-drawn circles, ellipses, and arrows to add these to the computer generated displays at the NTC. Many of the computer-generated displays at the NTC include a symbol for every weapon system, leading to a rather cluttered display for battalion sized groups.

Nelson ([11]) considers meaningful ways of using graphic symbols to represent company, or larger, groups as a whole, requiring considerably fewer symbols on a computer display. He specifically addresses the above features (type and size, centroid, spatial arrangement, direction and rate of travel) in replacing individual symbols by unit symbols. He suggests using standard military symbols for identifying units, with the center of the symbol at the unit's centroid position (at a given time point). location of the centroid can be defined in several different ways; Nelson discusses the merits of the (x-mean, y-mean) pair, trimmed mean pairs, and the (x-median, y-median) pair for this purpose.

Similarly, the dispersion of a unit at a given time can be pictured in many different ways. To give the most realistic representation of unit dispersion at a given time, he considers a number of different convex shapes, centered at the centroid, which contain a given fraction of the members of the unit. The ellipse is considered a useful shape to employ, as is the "convex hull". This latter shape has the advantage of giving more detailed information than does the smoother looking ellipse.

Figure 5 shows a prototype display of these features for two company sized armor units over 25 minutes of a battle, representing actual company movements from a battle fought at the NTC. The small rectangles are standard military symbols representing the type and size of the units. They are centered on the unit centroids, which are the (x-median, y-median) pairs of the two companies. The small circles in Figure 5 denote the centroids at 5-minute increments; the track covered is evident, with the rate of advance being given by the distance between successive centroid locations. The relative movement of the two companies is easily comprehended. The final arrowheads indicate the line of future movement and actually locate the centroid positions at the next time point. This figure uses the convex hull representation of the unit dispersions. These polygonal figures contain the 75% of the unit members which are closest to the centroid. The sharp corners thus indicate individual unit locations, a feature not present with smoother ellipses or circles which are also discussed in [11].

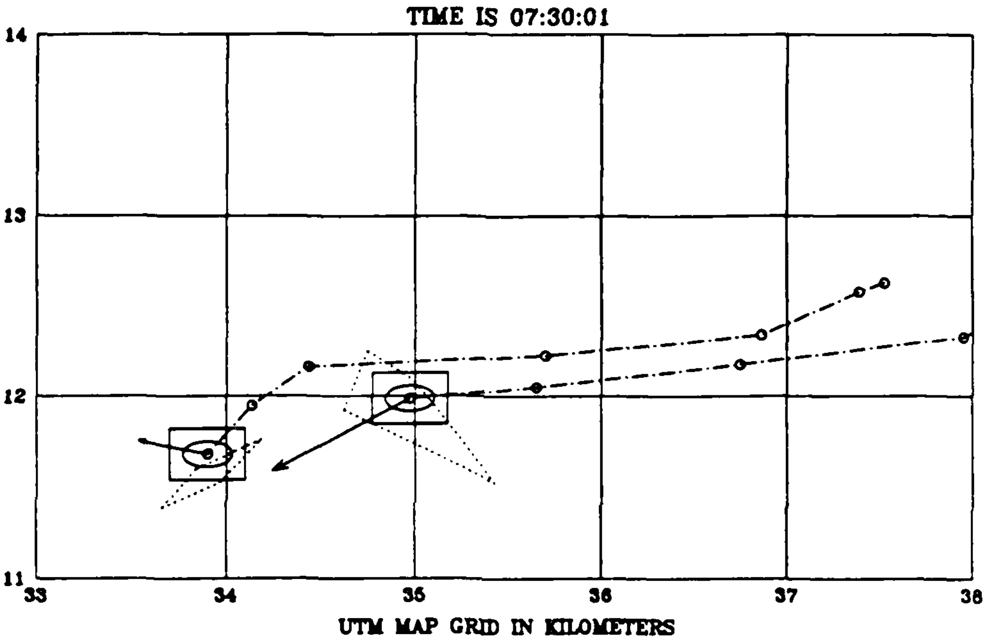

Figure 5. Maneuver of two tank companies over 25 minutes of battle.

Overlaying a terrain map with Nelson's unit symbology (for both sides) gives an uncluttered view of the dynamics of a battle. Animation (at some time increment) with the ability to pause at selected times will provide a powerful tool for critiquing performances encountered in unit training.

Figure 5 was developed by Major Nelson using the programming language *APL2* and the interactive software system *A Graphical Statistical System* (AGSS) at the Naval Postgraduate School under a test site agreement with IBM Research. We are indebted to Dr. Peter Welch for making this possible.

User Interface

The current candidate BEAM User Interface is pictured in Figure 6. This has been discussed with personnel at both the TCDC and the NTC for possible modification (as well as others). As pictured here, the user would select one of the current tenets, the scenario type, the Battlefield Operating System (BOS) of interest, as well as which aspect of the tenet-BOS combination is of interest. This would then bring to the screen an appropriate display for the combination selected. For many of the planned displays, animation would seem useful and appropriate, as would the possibility of choosing additional overlays beyond those supplied by default. For these cases there would be

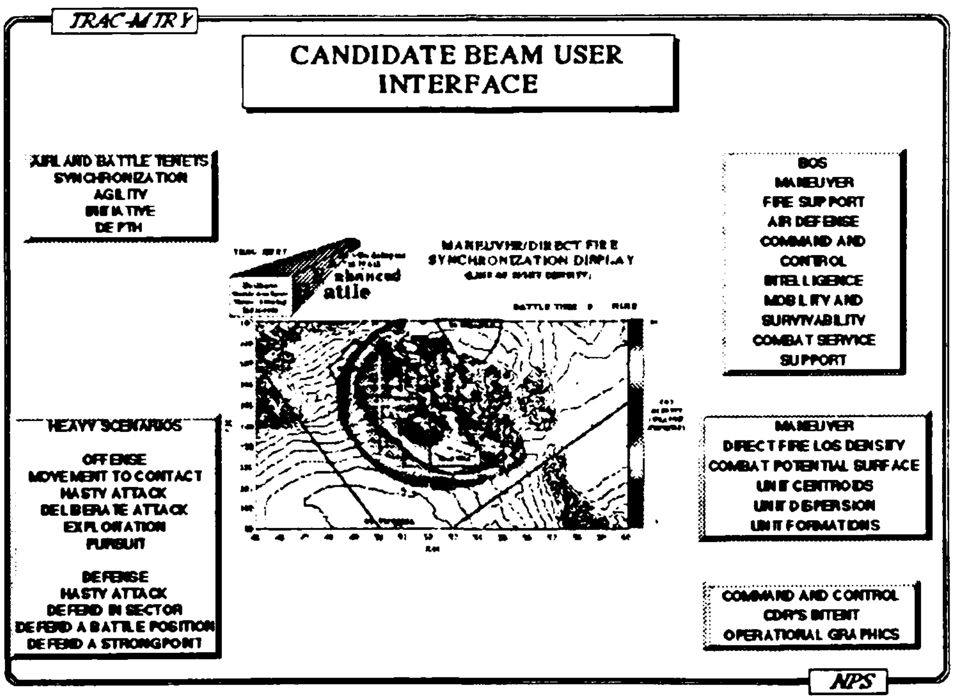

Figure 6. Suggested user interface for displays.

additional options describing the time increments available for the animation, and the additional overlays which might be of interest.

Conclusions

The BEAM project has produced a number of displays that are useful in portraying synchronization of forces, especially for defensive scenarios. It is expected that slight modifications of the LOS and DP displays will also provide good descriptors for attack scenarios. A time trace of the maximum value of a DP display, together with the enemy's maneuver display (small multiples), will give one way of portraying the agility of a tactical force. This symbology developed to describe the movement and maneuver of an armored company over time is equally applicable in displaying the maneuver of larger sized groups as well.

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